KRADLE

a user's manual

K2 ELECTRONICS DESIGN CORPORATION
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Installation IS Required - Instructions on Page 4

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KRADLE User Manual
By R.P.L.

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I. Introduction to Your New KRADLE

I.A. Features

KRADLE eliminates the major deficiencies of your Timex / Sinclair computer with a full-sized 50 key keyboard, 64K bytes of RAM, a cassette read enhancer, a joystick interface, and other good things in a compact metal case that also holds your fully assembled computer. KRADLE installs easily and requires no computer disassembly. Its low-power design runs cool, using your present power supply, and special circuitry and the all-metal package help minimize TV interference.

KRADLE's conventionally styled keyboard uses tactile "click" switches and has a wide space bar with double width keys for Enter and two Shift keys, plus nine extra keys that are automatically shifted :

- Function
- Edit
- Graphic
- Delete
- List
- four Cursor Arrows

The legends on and around KRADLE's keytops are color coded (like your computer's) and very wear resistant.

KRADLE has a full 64K of RAM under a flexible memory mapping scheme that is compatible with existing RAM packs. Even memory mapped peripherals fit with minimal loss of usable memory space. BASIC can use the top 48K for programs and data, while all but the top 16K is usable for machine language programs. Two blocks of 4K can be individually disabled via switches, and the bottom 8K can be switched between ROM to RAM under software (machine language) control.

KRADLE includes a Cassette Read Enhancer that makes tape recorder playback volume less important. It suppresses hum and noise and prevents a "ground loop" so both cassette cables can remain connected at all times. Tapes will load easier and more reliably, often even eliminating the need for an external filter with "fast load" routines.

KRADLE's top mounted pilot light tells when the computer is powered. Improved reset circuitry in KRADLE starts your computer properly every time, also preventing operation under normally undetectable low supply voltage conditions. This reset circuit is insensitive to how big or small a power supply is used, or how fast or slow it turns on.

On KRADLE's back panel is a joystick connecter that matches with Atari 2600 TV-game joysticks, letting it act as the "Graphic" and four arrow keys. The back panel has new connectors for EAR, MIC, and 9V DC, as well as an extension of the computer's bus for use with standard peripherals and ROM packs. Two extra openings on the back allow KRADLE to support plug-in expansion options, such as the KRADLE Communicator - serial expansion with real RS-232 capability, and the KRADLE Manipulator - parallel expansion with 16 (+4) lines of digital I/O.

I.B. Capabilities

KRADLE is intended to address the hardware faults of the Timex / Sinclair personal computer, in particular its membrane keyboard and lack of memory, without introducing further limitations. The improved keyboard makes your computer easier, faster, and more enjoyable to operate. Its layout was enhanced to facilitate normal typing and speed cursor manipulation since rapid cursor use is desirable for editing and often required for simulations and games.

KRADLE provides as much memory as the typical user will ever need, indeed more than the computer can easily handle. A full 64K bytes allows the Timex / Sinclair to simultaneously hold a large BASIC program, much data for that program, multiple large machine language programs and their data, even a RAM based (and hence user modifyable) copy of the computer's ROM operating system. The memory design allows standard plug-on modules, both ROM and memory-mapped I/O, to automatically take precedence over KRADLE's RAM. The loss of RAM is limited to that demanded by the installed module(s). Switches are provided to disable memory from 8K to 12K and from 12K to 16K, but they will not normally be needed because of KRADLE's exclusive precedence logic.

Since memory-mapped I/O takes up RAM space, KRADLE I/O and expansion options are done with port I/O which does not affect memory use. KRADLE port assignments conform to the Sinclair philosophy and should be compatible with future products from the computer's manufacturer as well as those in existence today (see section VI.D, page 17).

KRADLE's cassette read enhancer is a selective filter and squaring circuit, configured to work well with the computer's audio encoding method and hardware. The filter design, however, was kept broad enough to work with fast cassette schemes that can utilize lower cost cassette recorders.

Having put all of these features into KRADLE it became very economical to add expansion capacity to it. The KRADLE Communicator serial port and KRADLE Manipulator parallel port fit easily into the KRADLE'd computer from hardware and software viewpoints. The Manipulator provides a Z-80 PIO device with 16 uncommitted outputs and four handshake lines, a combination virtually unlimited in use for monitoring real-world events, effecting device control, or implementing high speed parallel data transfer among computers and peripherals. The KRADLE Communicater provides a full RS-232 compatible serial port with all handshaking lines, and is suitable for linking with modems and/or other computers for data exchange. All Communicater parameters are software controlled except for the strappable choice of Terminal (DTE) or Modem (DCE) connector configuration.

II. Getting KRADLE Ready to Use

II.A. What comes with your KRADLE

The following items are included in the KRADLE package:

1. The KRADLE keyboard with RAM
2. This Manual

II.B. Assembling Computer and KRADLE

{Please read and understand the following instructions completely before starting the procedure.}

In order to put your KRADLE to use it must first have your Timex / Sinclair computer installed in it, a simple task that requires a few minutes of time, a clean workspace, and a phillips screwdriver. The KRADLE paint finish is quite durable but it would be wise to use a soft cloth over your work surface to help prevent any scratches. Remove your KRADLE from its packing box and place it upside down on the cloth, with the rear panel away from you. Note that there are five screws on the bottom. Remove only the four corner screws and set them aside.

Try to keep the back edges of the top and the bottom together for the next two steps. Grasp the bottom cover by its sides and carefully lift the front edge up about eight inches. If you peer under the bottom you will see a wide flat cable connecting the top to a small circuit board in the bottom. Make a note of how this cable is fitted to the small circuit board, then reach in and unplug it. Place the bottom in front of you and the top just beyond it.

Find the two audio cables in the top of KRADLE. One goes to the computer's EAR jack, the other to the computer's MIC jack. If a cable is marked "E" it goes in the EAR jack, if marked "M" it goes in the MIC jack. Plug the marked cable(s) in now. If one of the cables is not marked plug it into the other cassette recorder jack. The front most computer jack (labelled "9V DC") is not used. Also plug in the TV cable that you use with your computer, being careful to route it through the designated hole on KRADLE's rear panel.

Attached to the front inside case bottom is a metal clip that will be used to hold your computer in place. Loosen the screw holding this clip and remove the clip. Notice that the circuit board in the case bottom has a connector on its front edge. You should now plug your TS-1000 / ZX-81 into this connector. Re-install the mounting clip over the front of your computer, install the screw, and tighten moderately.

Warning: It is possible your favorite peripheral (add-on module) MUST be placed between the computer and KRADLE's memory. Normally you could consult the peripheral's manual to check this, but one supplier confuses the issue by saying to place his modules "before the memory" only because of package shape! Expect this requirement to be true only for devices like high resolution graphics adapters (HRG). See section VI.C on page 16 for additional information. If your module must be placed between the computer and memory then your computer and

add-on pair may not fit unmodified within the KRADLE. The easiest solution to this is to remove the Timex / Sinclair's circuit board from its case and use it uncased. This is done by removing the computer's feet to expose all five bottom screws, removing the screws and bottom case half, removing the remaining two screws which hold the circuit board, and disconnecting the keyboard cables (they pull out hard). If you install this uncased board in the KRADLE you will have to fabricate your own front clamping arrangement for this non-standard configuration. Also make sure you have the channel 2-3 switch set properly as it is no longer easily accessed.

(If you have the Communicator serial I/O or Manipulator parallel I/O add-in expansion options now is a convenient time for installing them. Refer to the instructions included with the add-in for full details.)

While you have your KRADLE open take a look inside the top half. The main KRADLE circuit board is to the rear and has the connectors which you will now use for power and tape recorder cables. To the outside of these is the joystick connector, and to the inside is a small 4-section DIP switch. The switch is used to control memory in the 8K to 16K range, and works as follows:

Switch	Memory range	"ON"	"OFF"
1	8K to 12K	readable	hidden
2	12K to 16K	readable	hidden
3,4	(not used)	(leave on)	

Make sure switches 1 and 2 are set ON now. These switches are normally left ON even if you use peripherals mapped between 8K and 16K. Such peripherals must turn off the computer's ROM when in use. KRADLE also makes itself invisible during that time. The only time these would be set to OFF is when you don't want a given memory range to respond at all, or you are using a memory mapped peripheral in the 8K to 16K range which must be mounted between computer and RAM.

Your KRADLE is now ready to go back together. Swing the bottom back over onto the top, being careful not to pinch the audio cables. Put two screws in the front corners, but leave them slightly loose. Now turn your KRADLE over so it rests on the bottom with the rear facing you. Make sure your TV cable is coming out the lower right hole of the rear panel. Lift up on the rear of the top and notice the wide cable you previously unplugged. Reach in and, making sure it is correctly aligned, plug it back onto the small circuit board. It should snap into place with no connector pins visible. Close the rear of the case and invert the KRADLE again. Put in the remaining two bottom screws and tighten all four screws. This completes the assembly procedure.

II.C. External Cable Connections

With the computer safely nestled in its KRADLE you can proceed to hook it up to the outside world. The TV cable is already plugged into the computer. Rear panel phone jacks for MIC, EAR, and 9V DC are used just like those of the computer, as is the rear bus extension connector. The joystick connector does not require any device be plugged into it, but accepts standard joysticks and their (electrical) equivalents.

III. Quickly Testing Your KRADLE

III.A. Putting power to KRADLE

Given that you have installed your computer into KRADLE it's reasonable to try some quick tests to show that everything works. (If you don't want to do any testing jump ahead to page 9.) With your 9V power supply disconnected from its source of electricity connect it to your KRADLE. Connect the TV cable and apply power to the TV, allowing time for it to warm up. Now connect the 9V power supply. The screen should stabilize and, after about 4 seconds, the cursor K appears. (The computer takes a while to clean out and set up a large memory.) The KRADLE power-on LED should also be brightly lit.

III.B. Keyboard

If you want to familiarize yourself with the keyboard and test out its circuitry the following sequence does so without having to use all 50 keys. Type in the numbers 1 thru 5, they should appear on the screen in order. Use the left and right cursor keys (right of space bar) to move about the group. Use the DELETE key to erase the digit 1. Move the cursor to after the 5 and enter the keyword REM (on key E), followed by this sequence: X S W 2 7 U J M. They should appearin order on the screen. Note that the GRAPHICS key changes the cursor from L to G and back, while FUNCTION changes it from L to F and back. Press ENTER, your line should move to the screen top. Press LIST, you should see LIST at the screen bottom. Press EDIT, the word LIST disappears with a copy of the top line now displayed at the bottom. Press DELETE to erase the digit 5, then ENTER which moves the line above the 2345 line. Now use the up and down cursor keys (left of space bar) to move the line pointer between the two lines. This completes the keyboard circuit test.

III.C. Joystick Connector

Do you have a joystick or trackball? Why not try it out now? Just plug it in. It should work just like the cursor keys and can be used for editing as well as games and simulation. The "fire" button acts the same as the GRAPHICS key. For programs that will use a joystick the following keycodes should be used: Up - 112, Down - 113, Left - 114, Right - 115, Fire Button - 116.

III.D. Memory

Assuming that you are feeling comfortable with KRADLE's new keys perhaps it's time to put in a program to test memory. If you left a switch on for RAM at 8K - 12K use this program to check that area of RAM:

```
 10 FAST
 20 LET S=8192
 30 LET F=12287
 40 LET B=0
 50 LET M=85
 60 GOSUB 140
 70 LET M=170
 80 GOSUB 140
 90 IF B=1 THEN GOTO 120
100 PRINT "MEMORY IS OK FROM ";S;" TO ";F
110 STOP
120 PRINT "MEMORY PROBLEM DETECTED"
130 STOP
140 FOR I=S TO F
150 POKE I,M
160 NEXT I
170 FOR I=S TO F
180 IF PEEK (I)=M THEN GOTO 210
190 PRINT "MEMORY LOCATION ";I;" IS BAD"
200 LET B=1
210 NEXT I
220 RETURN
```

This program takes just over three minutes to run if no errors are found. For RAM at 12K - 16K use the same program but with the following lines changed:

```
 20 LET S=12288
 30 LET F=16383
```

Testing memory normally used by BASIC is not quite so easy. The test program, its variables, and the display must not overlap the memory being tested. The commands and program following directly check all memory above that actually required to run the program, while indirectly checking the memory used by the program. Don't expect this to be quick since it checks over 44K of memory, requiring over fifteen minutes to do so.

Before entering this program, enter

```
POKE 16388,0
POKE 16389,68
NEW
```

to lower RAMTOP to the 17K level so that the test will not interfere with active memory.

```
 10  FAST
 20  LET S=17407
 30  LET F=65346
 40  LET D=188
 50  LET B=0
 60  FOR I=S TO F STEP D
 70  FOR J=1 TO D
 80  POKE I+J,J
 90  NEXT J
100  NEXT I
110  FOR I=S TO F STEP D
120  FOR J=1 TO D
130  IF PEEK (I+J)=J THEN GOTO 160
140  PRINT "MEMORY LOCATION ";I+J;" IS BAD"
150  LET B=1
160  NEXT J
```

```
170  NEXT I
180  IF B=1 THEN GOTO 210
190  PRINT "MEMORY IN 17-64K RANGE IS OK"
200  STOP
210  PRINT "BAD MEMORY EXISTS IN 17-64K RANGE"
```

These memory tests pretty much prove that your 64K memory is performing adequately for normal operation, but only a program with machine language instructions will check that the memory can work as fast as the computer's CPU chip needs it to. This next program runs machine language instructions by using subroutines written in machine language to copy the computer's ROM into RAM, then switch between ROM and RAM. The computer will black out its display when ROM is off and all 64K of RAM is turned on. (The first line has 28 periods in it.)

```
 10 REM ........................
 ...
 20 FAST

 30 LET A$="062 001 001 127 127 2
 37 121 201 062 002 001 127 127 2
 37 121 201 033 000 000 017 000 0
 00 001 000 032 237 176 201 "

 40 LET ADR=16514
 50 FOR I=1 TO 110 STEP 4
 60 LET B=VAL (A$(I TO I+2))
 70 POKE ADR,B
 80 LET ADR=ADR+1
 90 NEXT I
100 LET B=USR 16530
110 SLOW
120 FOR I=1 TO 8
130 LET B=USR 16514
140 PRINT "RAM"
150 LET B=USR 16522
160 PRINT "ROM"
170 NEXT I
```

If you see your display blink on and off then you know this program is running properly, memory works fast enough, and you now have the ability to use all 64K of RAM. For more information on using all 64K of RAM refer to section V, page 12.

III.E. Cassette Read Enhancer

Since the Cassette Read Enhancer is a "hidden" feature of the KRADLE it is difficult to test how it is performing, but you can test that it is working. To do so try loading a rather short program repeatedly, each time with a lower volume setting. You should notice that the recorder's volume control setting is now less important than it used to be. The enhancer does not affect how or what is written to the tape and should not be noticeable during normal operation. Most schemes for fast loading and saving should work with KRADLE's enhancer. If you have a fast loader that uses a filter box KRADLE may be good enough to work without the filter box. Give it a try!

IV. Using Lots of RAM

IV.A. With BASIC In General

Your computer was designed by people who never expected it to have over 16K of RAM, so it needs some help from you to learn that it has more than that to work with. The first step is to tell BASIC that it has more memory by adjusting the value in memory called "RAMTOP". Type in the following BASIC commands:

```
POKE 16388,255
POKE 16389,255
NEW
```

Notice that it takes BASIC many seconds to clear out its memory when you type NEW. Anytime you want to know "RAMTOP" just use the command sequence:

```
PRINT PEEK 16388+256*PEEK 16389
```

The number it prints (65535 or less) is one more than BASIC will attempt to use. Chapter 26 of the manual that came with your computer will show you how BASIC utilizes memory. If you look there you will see that BASIC puts the program starting at 16509 with the display file and variables following. Unfortunately the display file must end below 32768, limiting the size of BASIC program that can be put into memory to just over 15K bytes. (This is an inherent hardware limitation of the computer's display scheme and cannot be changed.) The rest of memory below RAMTOP is still usable for data storage and stacks. With RAMTOP at 65535 let's see what BASIC can really do!

One test is to RUN a one line program which dimensions a very large array. An ending report code of 0/10 means all is OK. Just type:

```
NEW
10 DIM A$(100,481)
RUN
```

or

```
NEW
10 DIM B(100,96)
RUN
```

BASIC needs over 48,000 bytes to run each of these! Since BASIC can only make use of the top 49,152 (48K if K=1024) bytes the following programs should end with an out of memory report code of 4/10:

```
NEW
10 DIM A$(100,482)
RUN
```

or

```
NEW
10 DIM B(100,97)
RUN
```

From the previous examples you can see that your computer can store only about 9,700 numbers while a string array can hold over 48,000 characters. One technique for squeezing variable space is to use a string variable or array to hold integer numbers less than 256. This is done by converting each number to a character (via CHR$) before saving it in the variable. When reading back such a "number" remember that it comes as a single character and must be restored to proper numeric form via CODE. (The program on page 13 uses this technique.)

IV.B. With BASIC Programs You Already Have

Your computer is designed to save a program's variables automatically when it saves the program, along with other important "machine information." LOADing a tape restores this information and puts it to use when needed. Any program that runs in 16K will run on KRADLE, but if it has data stored with it you can't easily make it use your new, larger memory. That "machine information" includes available memory size, now a wrong number. To use all the available memory of KRADLE requires that you re-dimension array variables, and BASIC can't do this without erasing the data in ALL its variables. The only simple solution is to:

LOAD your program and data
EDIT (if needed) the program to add a routine that LPRINTs
or PRINTs out the array data
GOTO the routine that does the data printout
EDIT your program to have new and larger array sizes
RUN the program and re-enter the data as printed out

KRADLE is unique in how it handles the "display file" and memory for machine language programs. The people who designed your computer never intended it to run machine code above the 32K line. Instead they defined any "instruction fetch" cycles above 32K to be only for accessing the video display data. Most memory add-ons are limited by this same thinking. The KRADLE, however, uses 48K for that dividing line without affecting normal computer operation. You can put machine code anywhere in the bottom 48K, provided it's below 16K, above RAMTOP, or otherwise protected from BASIC, and it will work as it should. (This same feature in KRADLE is what allows BASIC to utilize the entire memory from 16K to 64K.)

To summarize the memory capabilities:

0 to 16K	machine code (see section V.)
16K to RAMTOP	BASIC program, the display file, and variables (note: RAMTOP defaults to 32K max. on power-up) RAMTOP can be as high as 64K (65,535)

And if RAMTOP is less than 48K (49,152):

RAMTOP to 48K	Machine Code and read/write memory
48K to 64K	Read/Write memory only

IV.C. Cassette Storage of Large Programs

The use of cassette storage for large programs is reasonable only if the cassette interface is fast and reliable. The Timex / Sinclair computer does not have a fast tape interface built in, so its designers did not supply fast cassette software. KRADLE supplies a reliable "fast" interface, in the form of a read signal enhancer, usable with various fast cassette schemes. If you do not already have one of these software (or software/hardware) packages it is the recommendation of KRADLE's designers that you acquire such software to increase the utility of your computing system.

V. KRADLE RAM Below 16K

V.A. 8K to 12K
12K to 16K
Plug-on ROM Packs

This section is for those of you who want to run one or more machine language programs that fit below the 16K line. Such programs would be a fast tape routine, a spreadsheet, an assembler, or a plug-on ROM cartridge. If your interest is for an I/O device refer to section VI.C, page 16.

Given that you have chosen to let BASIC have all the memory it can use, 16K to 64K, where do you put machine language (ML) programs and routines? With a second, unused image of the computer's ROM normally at 8K to 16K BASIC never attempts to use this range of memory. KRADLE fills 8K to 16K with RAM (if the switches inside KRADLE are ON) overriding the computer's ROM and providing a safe area to put ML code, just like other 64K memory units. Much software supplied on cassette for "64K" machines uses this RAM area and should work fine.

A problem occurs if two ML programs load or run on top of each other, both attempting to use the same memory locations for program or data. In this case one must be "relocated" to fit after the other and use seperate memory locations. Some programs can be moved without change, but this is not usually the case. BEWARE! Make sure the programs you acquire won't conflict or are supplied with information on how to re-locate them. (Often only the program's author or other Z-80 expert can tell if a program is relocatable. This is done by examining the source code, or a proper disassembly of the ML code.)

Some software for your computer is supplied in the form of a plug-on module or ROM pack, and is invariably located in the 8K to 16K range. Usually you would have to switch off RAM where the module is addressed, but not so with KRADLE. KRADLE senses when these modules attempt to turn off the computer's ROM image and makes itself invisible as well. A proper ROM pack will do this only where it needs to and, if the ROM is less than 8K long, leave some RAM available for your ML routines. The problem comes when the software supplier puts out a 2K or 4K ROM pack that uses up all 8K of space, saving himself a few pennies while wasting 4K or 6K of your memory.

The solution to this is to copy the ROM to tape, power down, remove the ROM pack, power back up, and copy the tape back into low RAM along with your other program(s). The following program will copy low memory (RAM or ROM) into a string savable under BASIC, which can be later read back in and moved back into low RAM.

(section V.A. continues after the program)

NOTE: K2 ELECTRONICS DESIGN CORPORATION DOES NOT ADVOCATE THE VIOLATION OF COPYRIGHT LAWS AND PROVIDES THE FOLLOWING PROGRAM SOLELY FOR THE BENEFIT OF INDIVIDUALS LEGALLY ENTITLED TO USE IT. ANY OTHER USE IS STRICTLY PROHIBITED AND SUBJECT TO PROSECUTION.

1. Remove power, install the ROM pack, restore power.

2. Enter the following program:

```
 10 FAST
 20 DIM A$(8192)
 30 LET START=8192
 40 LET END=16384
 50 LET LIMIT=END-START
 60 FOR I=1 TO LIMIT
 70 LET A$(I TO I)=CHR$ (PEEK (START+I-1))
 80 NEXT I
 90 SLOW
100 PRINT "START RECORDING, THEN PRESS ANY KEY"
110 IF INKEY$="" THEN GOTO 110
120 SAVE "ROM"
130 PRINT
140 PRINT "ENTER  S  TO SAVE ANOTHER COPY ON TAPE"
150 PRINT "       L  TO LOAD FROM TAPE INTO RAM"
160 PRINT "       X  TO STOP FOR REMOVING ROM PACK"
170 INPUT B$
180 IF B$="S" THEN GOTO 100
190 IF B$="X" THEN STOP
200 FAST
210 FOR J=1 TO LIMIT
220 POKE START+J-1, CODE (A$ (J TO J))
230 NEXT J
```

3. Save the program to tape normally, for later use.

4. RUN the program to copy the ROM into the BASIC variable A$. After some two minutes the program prompts you to start recording. Do so then press any key (except the space bar).

5. Remove power, remove the ROM pack, restore power.

6. LOAD the program and data saved above. It will automatically copy the ROM's contents back into RAM at the same addresses.

7. Other software may now be loaded into low RAM.

NOTE: ROM based software may not run properly when first executed from RAM. It is sometimes "protected" by requiring multiple copies of itself to work properly, or by attempting to write over itself when initally executed. The former is very difficult to eliminate but does not prevent running from RAM. The latter requires that you find the offending "write" routine and replace it with instructions called NOPs (no ops), the machine code that performs no-operation but takes up space and preserves program continuity.

V.B. 0 to 8K

In the Timex / Sinclair computer the use of RAM below 8K is normally impossible, not so with KRADLE. The design of the computer's ROM circuit causes the display to go blank when RAM is used, but useful computing can still be performed and the display returns with contents intact when the ROM is switched back on. The use of RAM below 8K is not typically useful but does permit a machine programmer to "modify" the ROM without having to actually remove and replace it. Since only a machine programmer should use this feature just a summary of the appropriate routines is given here. More information is available in sections VI.D (page 17) and VII.A (page 20). Remember to copy ROM to RAM before doing the switch!!!

```
decimal       hex
-----------   --------

                        ; Subroutine to select RAM
062 001       3E 01     GORAM: LD A,1       ;To select RAM: data=xxxx0001B
001 127 127   01 7F 7F         LD BC,7F7FH ;KRADLE's map control port
237 121       ED 79            OUT (C),A   ;register indirect
201           C9               RET

                        ; Subroutine to select ROM
062 002       3E 02     GOROM: LD A,2       ;To select ROM: data=xxxx0010B
001 127 127   01 7F 7F         LD BC,7F7FH ;KRADLE's map control port
237 121       ED 79            OUT (C),A   ;register indirect
201           C9               RET

                        ; Subroutine to copy ROM to KRADLE RAM
033 000 000   21 00 00  DUP:   LD HL,0     ;from 0
017 000 000   11 00 00         LD DE,0     ;to 0
001 000 032   01 00 20         LD BC,2000H ;8192 times
237 176       ED B0            LDIR        ;copy, increment, repeat
201           C9               RET
```

A sample program using the above routines was given on page 8. In it the variable A$ is initialized with the decimal byte values of the machine code routines. These values are then poked into a REM statement at the beginning of the program. Using this technique the machine language routines become USR subroutines at the following addresses:

```
GORAM = USR 16514
GOROM = USR 16522
DUP   = USR 16530
```

The display being blanked out is a result of the computer's technique for creating the video data. Each character requires reading the data RAM and then the character generator ROM, both within one "instruction cycle". Special hardware in the computer makes this possible, it cannot be readily switched over to use a RAM based character generator.

VI. Using KRADLE with Your Peripherals

VI.A. Power Supply Limitations

Your computer probably came with a power supply whose output rating is "9.75V DC 650mA". The significant value is 650mA, which is just enough for computer and KRADLE. To safely run any peripherals your power supply should be rated 650mA plus whatever your peripherals require. A power supply rated in amps (A) puts out 1000mA for each 1A. **DO NOT USE ADD-ON PERIPHERALS THAT OVERLOAD YOUR POWER SUPPLY** - it may work for a while before it overheats - but you could damage the power supply or cause a serious fire.

VI.B. The Bus Connector

On the rear of your KRADLE is an extension connector which has all of the computer's bus signals brought out on it. All of the lines go right to your computer except two (ROMCS-not and RAMCS-not) and these function just like those on the computer's bus do. Your peripherals should just plug onto the back of KRADLE and work straightaway. The only concerns in using the bus extension connector are "bus fanout" and the use of WAIT-not.

Bus fanout is the term for how many "unit loads" a bus can drive. A peripheral may require more than one unit load, and the definition of one "unit" may vary from manufacturer to manufacturer. The designers of KRADLE consider one unit load to be the same as one (1) LSTTL load, an electronics industry standard value. With KRADLE attached to your computer the bus fanout left is approximately two (2) LSTTL unit loads, typically enough to allow two attached peripherals. Under normal use bus fanout can be slightly exceeded without concern for damaging your computer. The only consequence likely to be seen is reduced system reliability, perhaps even erratic operation.

The use of WAIT-not has to be carefully watched in any Z-80 computer system which uses dynamic RAM memory chips. Having too long a WAIT can cause the memory to forget what it was supposed to remember. Your computer and KRADLE are just such a system, and when using the bus extension connector you have to be the watchful one. (Your computer and KRADLE do not normally use the WAIT signal.) Fortunately add-on devices usually handle WAIT correctly, causing no problem. These devices would be indicated as being "compatible with dynamic RAM modules".

The typical offenders are published articles for build-it-yourself peripherals. These add-ons will work with the basic Timex / Sinclair computer but were never tested with a dynamic memory system. In particular beware of any EPROM programmer design that uses WAIT-not to halt the processor during programming. KRADLE's dynamic RAM memory may not work properly if WAIT is active (low) for A) more than 1 millisecond at a time OR B) more than 50% of the time.

VI.C. Memory Mapped I/O

The designers of your computer did not intend it to be used with memory-mapped I/O, but they could not prohibit it. KRADLE's designers also prefer port I/O but do provide for the use of memory-mapped I/O. Special precedence logic within KRADLE automatically senses when a memory mapped device is active and disables KRADLE memory at the same address(es). This exclusive feature makes the use of memory disable switches unnecessary.

The computer's ROM software limits the use of memory-mapped I/O to certain address ranges. Essentially no memory-mapped I/O should exist below 8K (8192) or between 16K (16384) and the value in RAMTOP. Above 48K (49152) problems may occur because of how the video display works. If your peripheral is mapped (addressed) above 16K then you MUST choose to 1) set RAMTOP (see IV.A on page 9) below where your peripheral starts, or 2) remap (change the address of) your peripheral to between 8K and 16K. The first is easy but causes BASIC to lose some of its memory and fail to hold or run certain programs. The second just might be possible, if so the manufacturer of the peripheral can tell you how.

The range of 8K to 16K is most popular for memory mapped I/O since memory here normally holds a nonusable image of the computer's ROM. KRADLE (if the switches inside it are ON) fills this area with RAM and turns off the computer's ROM. Any I/O device in this range will also try to turn the ROM off, KRADLE watches for this and switches its RAM off during that time as well. A proper I/O device will do this only where it needs to and, if it needs less than 8K, leave some RAM available. (Check your peripheral's manual to see both what it needs and what it uses. You will probably be surprised by the difference.)

A special situation exists for certain types of memory-mapped I/O devices which intercept the bus between computer and memory, such as a high resolution graphics adapter that uses the computer's memory for its video memory. Devices like this MUST be used BETWEEN the computer and KRADLE, and must therefore be placed inside the KRADLE's case (see the warning on page 4). For this type of device you will have to disable -- switch OFF -- KRADLE's RAM where the device is addressed. To install your peripheral you will have to disassemble KRADLE. Just follow the instructions on pages 4 and 5, but turn OFF the switch that controls RAM where your peripheral is addressed. The switch used to control memory in the 8K to 16K range works as follows:

Switch	Memory range	"ON"	"OFF"
1	8K to 12K	readable	hidden
2	12K to 16K	readable	hidden
3,4	(not used)	(leave on)	

VI.D. Port Mapped I/O

I/O devices supplied by your computer's manufacturer are all "Port Mapped", i.e. in the port I/O space. Some ports are found inside the computer, such as its keyboard, and some ports are found in add-ons, like the printer, but all are designed to work together thru a carefully planned scheme of choosing I/O port addresses. KRADLE was built to fit within that scheme and should work with all present and planned I/O devices from the Timex / Sinclair people.

KRADLE, however, may not be so lucky with port mapped peripherals from other suppliers, particularly those that require special machine language software to drive them. KRADLE requires the use of port 7F (hexadecimal) and will conflict with any other port mapped device at that address. It is possible to move KRADLE to port BF but this requires disassembly and modification of internal circuitry that should only be done by a trained technician. (Please contact our factory if you determine that this is necessary for your application.)

KRADLE conforms to the Sinclair I/O addressing philosophy, but apparently few peripheral designers understand that philosophy since many incompatible designs have been built and published. It seems in order to present a discussion of this philosophy to clear the air about the proper use of port I/O addressing.

Every peripheral "device" on your computer must be told when it alone is selected (for an I/O operation) as no two devices should be used at the exact same moment. Each device has its very own select signal, a signal related specifically to that device's port I/O address. So that your computer's manufacturer could keep costs down a technique called "incomplete address decoding" was used in creating the peripheral device select signals. With incomplete decoding each I/O device responds to many addresses, it doesn't care which is used. As an unfortunate side-effect some addresses refer to more than one device, these addresses MUST NOT be used since no two devices can be at the same address for proper computer operation.

On Sinclair computers each address line A0 to A7 is expected to connect to and designate one device only. That device responds when its line (An) is low during an I/O command, hence each device responds to 128 different addresses and only one is proper! To access only one device you MUST keep the unchosen A0 thru A7 lines high during any input or output command. The table on the next page summarizes the proper port addresses.

(section VI.D. continues after the table)

ONLY THE FOLLOWING ARE VALID PORT ADDRESSES for your computer. DO NOT USE ANY OTHERS or things may not work right!!!!!

Address Lines								Port Address		
A7	A6	A5	A4	A3	A2	A1	A0	hex	dec	Assigned Port Device
1	1	1	1	1	1	1	1	FF	255	Display Control *
1	1	1	1	1	1	1	0	FE	254	Keyboard, Cassette
1	1	1	1	1	1	0	1	FD	253	Display Control
1	1	1	1	1	0	1	1	FB	251	Printer
1	1	1	1	0	1	1	1	F7	247	reserved (Microdisk?)
1	1	1	0	1	1	1	1	EF	239	reserved (Network?)
1	1	0	1	1	1	1	1	DF	223	reserved (RS-232?)
1	0	1	1	1	1	1	1	BF	191	USER ASSIGNABLE **
0	1	1	1	1	1	1	1	7F	127	KRADLE **

* This violates the rules but it alone is completely decoded at an address where no other device responds.

** "Bits A6 and A7 are ignored, so if you are a wizard with electronics you can use them yourself." ZX SPECTRUM BASIC Programming, page 159, first edition 1982, from Sinclair Research.

KRADLE and its add-in expansion boards (including the Communicator and Manipulator) are all port mapped at port 7F. Together these use more than one address, so how do we do it? The solution is thru "register indirect port addressing" which allows 256 combinations of "indirect" addresses A8 thru A15 for each of the "direct" port addresses above. This gives 512 effective port addresses available for KRADLE and user assignment. Since BASIC has no port I/O commands users have to resort to machine language routines to access I/O ports. The register indirect opcode mnemonic forms are:

```
LD  BC,portaddr     ;portaddr = 0xx7FH (KRADLE) or 0xxBFH (User)
                    ;with indirect address xx ranging from 00 to FF
OUT (C),r           ;to write to the device from register r

LD  BC,portaddr     ;portaddr = 0xx7FH (KRADLE) or 0xxBFH (User)
                    ;with indirect address xx ranging from 00 to FF
IN  r,(C)           ;to read the device into register r
```

KRADLE has the following indirect port addresses planned out for it and its add-in expansions:

Address Lines and Indirect Address									
A15	A14	A13	A12	A11	A10	A9	A8	hex	Assigned KRADLE Device
1	1	0	1	x	x	r	r	Dr	Manipulator Parallel I/O
1	0	1	1	x	r	r	r	Br	Communicator Serial RS-232
0	1	1	1	x	x	x	x	7x	KRADLE memory map select

Note that in the above the bits designated r are used to specify the register to be accessed within the selected device.

The following examples for manipulating KRADLE's port mapped devices are relocatable subroutines using the form and addressing shown above:

```
decimal      hex
                        ; Subroutine to select RAM
062 001      3E 01      GORAM: LD A,1       ;To select RAM: data=xxxx0001B
001 127 127  01 7F 7F           LD BC,7F7FH ;KRADLE's map control port
237 121      ED 79              OUT (C),A   ;register indirect
201          C9                 RET

                        ; Subroutine to select ROM
062 002      3E 02      GOROM: LD A,2       ;To select ROM: data=xxxx0010B
001 127 127  01 7F 7F           LD BC,7F7FH
237 121      ED 79              OUT (C),A
201          C9                 RET

                        ; Subroutine to toggle the ROM-RAM flip-flop
062 003      3E 03      OTHER: LD A,3       ;To toggle: data=xxxx0011B
001 127 127  01 7F 7F           LD BC,7F7FH
237 121      ED 79              OUT (C),A
201          C9                 RET


                        ; Subroutine to output byte
                        ; to selected register of Communicator
                        ; A = data  B = register
245          F5         OUTSER: PUSH AF     ;temporary save
062 176      3E B0              LD A,B0H    ;Communicator starts at B0
128          80                 ADD A,B     ;formulate register address
071          47                 LD B,A      ;put into proper register
241          F1                 POP AF      ;restore saved value
014 127      0E 7F              LD C,7FH    ;KRADLE's direct port address
237 121      ED 79              OUT (C),A   ;send it to the Communicator!
201          C9                 RET         ;and go back

                        ; Subroutine to input byte
                        ; from selected register of Manipulator
                        ; A = data  B = register
062 208      3E D0      OUTSER: LD A,D0H    ;Manipulator starts at D0
128          80                 ADD A,B     ;formulate register address
071          47                 LD B,A      ;put into proper register
014 127      0E 7F              LD C,7FH    ;KRADLE's direct port address
237 120      ED 78              IN A,(C)    ;get that byte
201          C9                 RET         ;and go back
```

VI.E. Changing the TV Channel

Since your computer is no longer readily accessible to you KRADLE provides a bottom opening to operate the channel 2 - 3 selector switch. The switch selects channel 2 when towards the center of the case, and channel 3 when towards the side of the case. For actuating the switch a small flat-bladed screwdriver is recommended.

VII. About KRADLE

VII.A. How KRADLE Works

(This section could get complicated but we'll try not to let it. A block diagram of KRADLE is given on pages 22 and 23. It would be good to look at it right now.)

The keyboard in KRADLE works essentially the same as that in your computer except for having moving keys and a snappy feel. It is port I/O mapped right on top of the computer's own keyboard port, and responds to the same instructions the same way. Normally this would be poor design practice but the custom logic chip in the computer allows for just such a thing with no ill effects! The extra keys are added by logic which automatically generates a "shift" key signal when any one of them is pressed. The joystick is just simply wired in parallel with five of the auto-shift keys.

KRADLE's RAM is quite different than that of the computer, much to your advantage. The memory itself is isolated from the mapping logic that determines when and how it responds. A special high-speed 512 byte PROM chip holds the memory map logic and determines the following items:

1) Which 16K block of RAM is to be used.
2) Which 4K sections of the block can be read from (the whole 16K block can always be written to).
3) When the computer's ROM should be turned off.

It bases its decisions on the following inputs:

1) The computer's current memory address.
2) The "instruction fetch" signal.
3) The bus extension ROMCS-not and RAMCS-not lines.
4) The two internal memory enable switches.
5) The memory map control port signal AllRAM.

The always writeable nature of KRADLE's RAM allows copying the computer's ROM into RAM. The I/O port controlled input actually selects between groups of memory maps, differing only from 0 to 8K. Other inputs pick and choose among various memory map sets, determining when reading is allowed and which 16K block gets read. The "when" is KRADLE's method for knowing to automatically disappear if a ROM pack or other memory-mapped device is installed. The "which" ability to move 16K blocks around gives BASIC the "real" block of 48K to 64K while fooling the video display, giving it the 16K to 32K block it needs instead.

A section called I/O Support and Port Mapping simply provides the select and control signals used by all I/O ports in KRADLE. The keyboard is one such port, the memory mapping control port another. Manipulating this latter port effects switching from ROM to RAM and back dynamically under software control. The port is always set to "ROM" when the computer is reset on power-up, and has no apparent effect if not used.

The Cassette Read Enhancer has a special balanced input low-gain bandpass filter tolerant of input phase reversals, ground loops, and other nasties. A Schmitt trigger then squares up the signal, restoring its level while suppressing noise during quiet tape passages.

KRADLE has its own power filter capacitor and 5 volt regulator so as to not tax the ones in your computer. KRADLE's reset circuit is a threshold sensitive design that works more reliably than the one in the computer. It's included mostly for good measure. The power-on LED is a high efficiency unit chosen to provide bright wide angle visibility while being a miser on power.

VII.B. Expansion Facilities

Inside KRADLE there are two connectors for plugging in circuit boards which hold I/O expansion devices, such as serial, parallel, A to D, D to A, sound generator, real time clock and timer chips. Convenient rear panel cutouts allow ready access for connectors or switches mounted on the expansion boards. The cutouts are sized for DB-25 connectors, but smaller ones can be used as well. Electrically each connector is capable of supporting a port mapped I/O device of up to 16 addresses. All device select decoding is already in KRADLE and the expansion board need have nothing more than a bypass capacitor, the I/O chip, and connectors. The first two expansion boards available are described below.

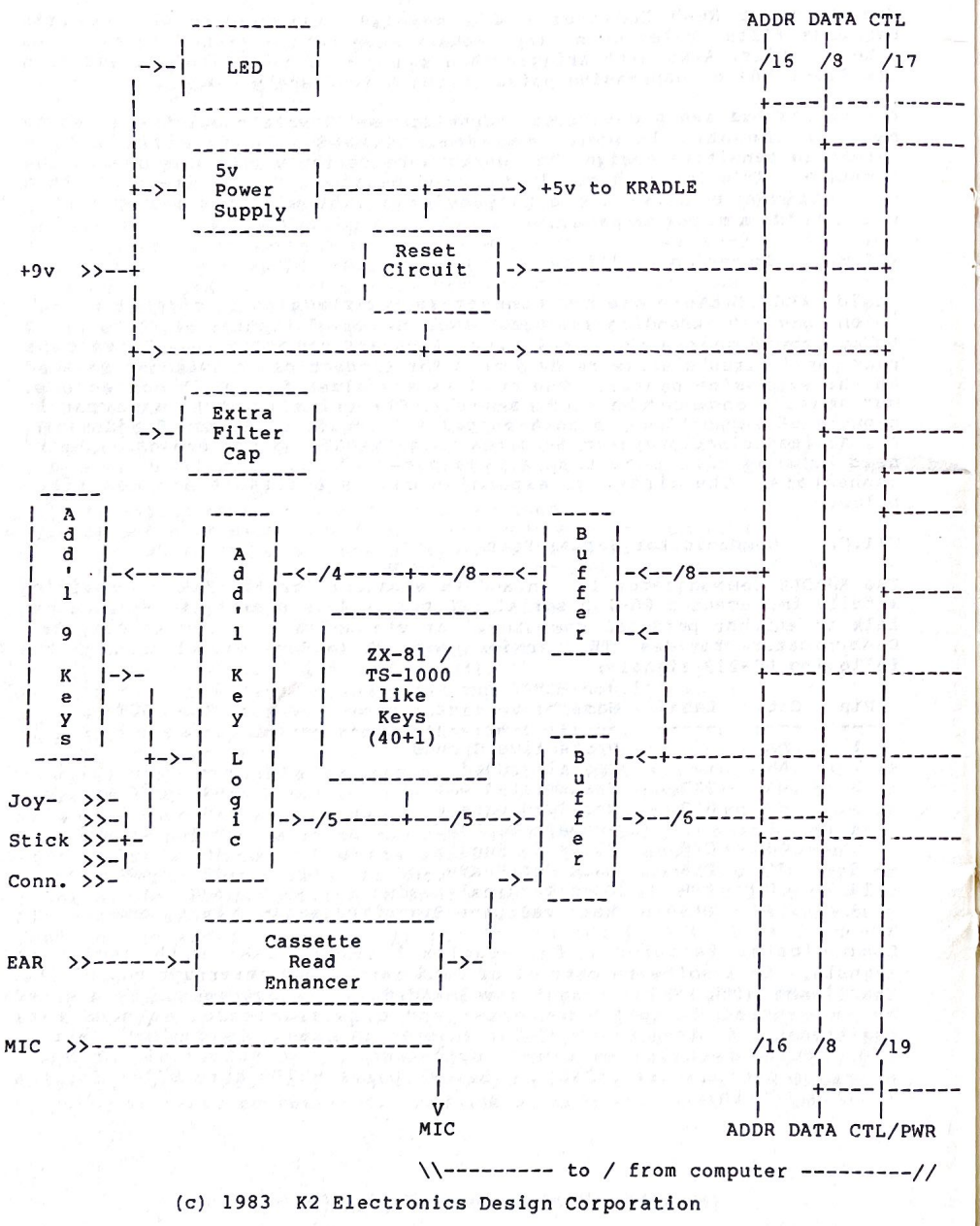
VII.C. Communicator Serial Port

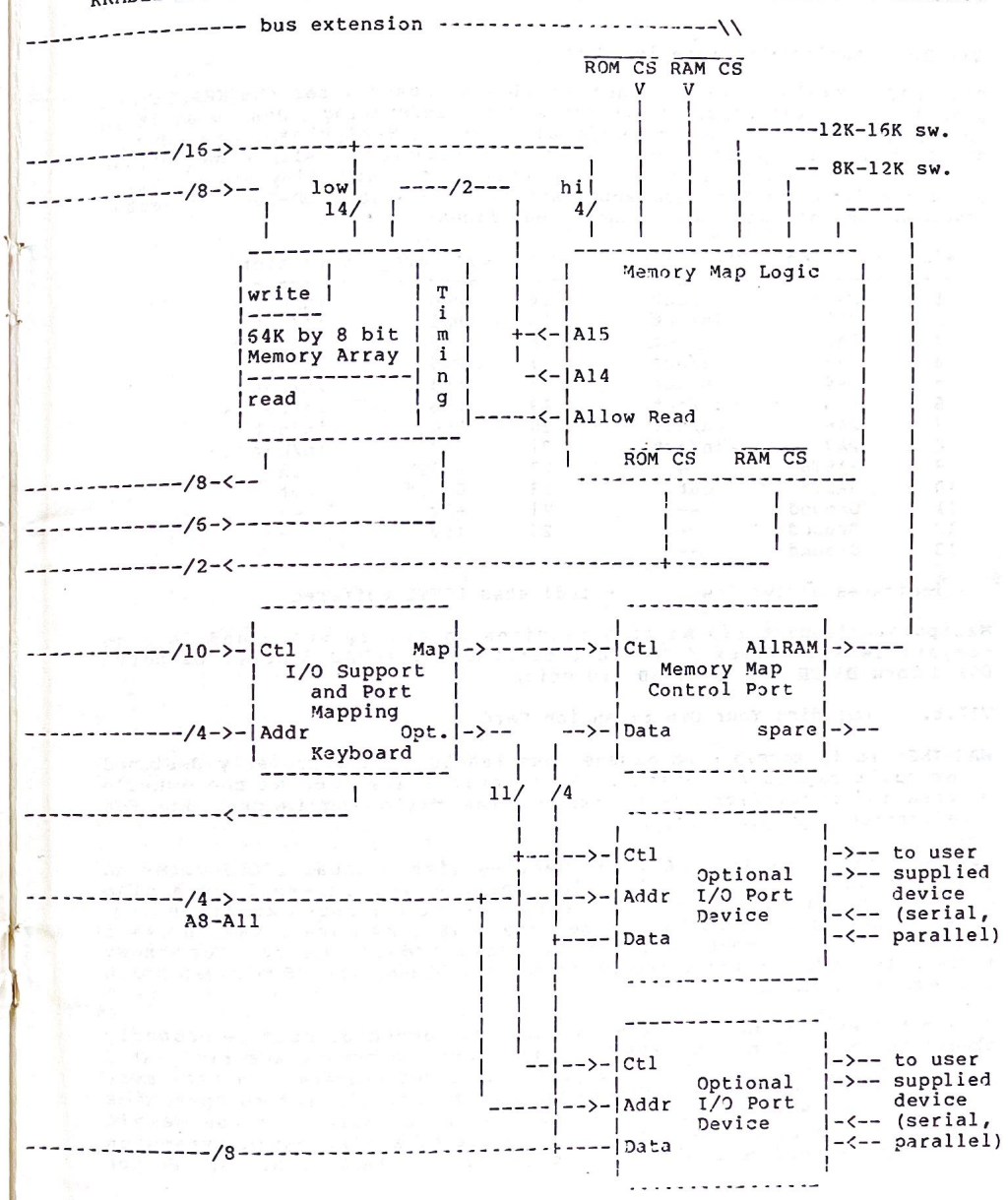
The KRADLE Communicator is an add-in expander for the KRADLE providing a fully implemented RS-232 serial I/O port. Just plug it in and you can talk to another personal computer, or via modem to a remote computer. Communicator provides DTE (terminal) or DCE (modem) emulation with the following RS-232 signals:

Pin	Ckt.	Label	Name	DTE	DCE
1	AA		Protective Ground	-	-
7	AB		Signal Ground	-	-
2	BA	TXD	Transmitted Data	out	in
3	BB	RXD	Received Data	in	out
4	CA	RTS	Request To Send	out	in
5	CB	CTS	Clear To Send	in	out
6	CC	DSR	Data Set Ready	in	out
20	CD	DTR	Data Terminal Ready	out	in
8	CF	RLSD	Received Line Signal Detector	in	out

Communicator features a full-duplex hardware UART with handshake signals, full software control of baud rate, and interrupt capability. Compliance with RS-232 signal level and timing requirements is assured by an onboard DC to DC converter and crystal controlled baud rate oscillator. A standard DB-25-S connector is used. Communicator's port I/O mapping requires no memory space and is compatible with Timex / Sinclair peripherals (KRADLE provides ports B07FH thru B77FH for the INS8250 ACE chip).

KRADLE Block Diagram





VII.D. Manipulator Parallel Port

The KRADLE Manipulator is another add-in expander for the KRADLE and provides two 8-bit parallel I/O ports with handshaking. Just plug it in to monitor or control up to 16 signals, or use Manipulator to talk to a standard parallel printer (external buffer required). All 16 data lines are provided without buffers to maximize user flexibility and minimize power requirements for each application. A standard DB-25-P connector provides the following power and signal lines:

Pin	Function	Direction	Pin	Function	Direction
1	PA0	in/out	14	PB0	in/out
2	PA1	in/out	15	PB1	in/out
3	PA2	in/out	16	PB2	in/out
4	PA3	in/out	17	PB3	in/out
5	PA4	in/out	18	PB4	in/out
6	PA5	in/out	19	PB5	in/out
7	PA6	in/out	20	PB6	in/out
8	PA7	in/out	21	PB7	in/out
9	-ASTB	in	22	-BSTB	in
10	ARDY*	out	23	BRDY*	out
11	Ground	--	24	+5v	--
12	Ground	--	25	+5v	--
13	Ground	--			

\- indicates active low * indicates LSTTL buffered

Manipulator's port I/O mapping requires no memory space and is also compatible with Timex / Sinclair peripherals (KRADLE provides ports D07FH thru D37FH for the Z-80 PIO chip).

VII.E. Building Your Own Expansion Card

WARNING: It is possible to damage your KRADLE with improperly designed or built expansion devices. Such devices are used at the owner's risk and invalidate the warranty. The following is provided for educational purposes only.

Do you have an interest in experimenting with unusual I/O devices on your computer? If so, KRADLE, through its internal expansion capability, provides a unique starting point for such experimenting. This is not recommended for the beginner but many more advanced users are capable of home-building a workable add-in board. For those individuals we'll describe the signals available on the 26 pin expansion connectors in KRADLE.

To use the expansion port signals a mating connector must be properly placed on your I/O board. KRADLE's expansion connectors are tin plated 26 position (2 x 13) .025" square post unshrouded headers. To mate most reliably the connector you choose should be very similar to Aptronics part number 929982-01-13, a tin plated right angle dual row female header. While it may be easiest, the use of a flat cable extension arrangement should be avoided due to signal crosstalk problems. Proper

placement of the connector is best determined by preparing a mock-up of your board in cardboard, then marking locations that match your connector to KRADLE's.

Unless indicated otherwise the following signals are identical to those on the computer's bus extension connector. Bus fanout is typically 2 LSTTL loads maximum. Signal -XS1 is the device select active (low) at addresses B07F thru BF7F, while -XS2 is active (low) at D07F thru DF7F. Your device must recognize -XS1 (or -XS2) during I/O accesses only and ignore it during memory accesses. Signals -IORD and -IOWR ease that task as they respond only for I/O reads and writes respectively. Further definition of the bus signals is beyond the scope of this manual, and can be found in any Z-80 hardware interfacing book.

Pin	Signal	Pin	Signal
1	+9v	2	-CLK
3	-IORQ	4	-IORD *
5	-NMI	6	-WR
7	-M1	8	-RD
9	-IOWR *	10	-XS2 *
11	RESET *	12	-XS1 *
13	D7	14	D6
15	D5	16	D4
17	D3	18	D2
19	D1	20	D0
21	A8	22	A9
23	A10	24	A11
25	Ground	26	+5v (150 mA max.) *

\- indicates active low * indicates KRADLE generated signal

VII.F Caring For Your KRADLE

Essentially KRADLE is a maintenence free item. There is nothing in KRADLE which would require user servicing during the normal lifetime of the unit. Your only obligation to KRADLE is to not abuse it. The keyboard is a long-life sealed snap-disc design, even at that it can be damaged by excessive force or a spilled beverage. The all-metal case is strong but was not designed to replace a chair seat or for crash testing on floors.

All connectors within KRADLE are designed to work well together and provide good service if they are not unmated and remated too many times. If you use the bus extension connector and swap add-ons often it would be good to keep it lightly coated with a "TV-Tuner" type contact cleaner and lubricant available in most radio supply stores.

KRADLE's case and keytops may get dirty in use, simply clean them with a soft non-abrasive cloth. Heavy accumulations may require the cloth be moistened (NOT dripping) with water and perhaps some diswashing detergent. Be sure to dry the unit well after such a cleaning.

Happy Computing!